# 3. FALL CREEK/WHITE RIVER TUNNEL

The Fall Creek/White River Tunnel will improve water quality in the Fall Creek watershed by capturing 43 combined sewer overflow (CSO) outfalls that currently discharge into Fall Creek and White River during wet weather events. The tunnel system will consist of a main tunnel; working, intermediate working, retrieval and drop shafts; a Deep Tunnel Pump Station; consolidation sewers; and connection tunnels. This section presents preliminary design information such as tunnel volume, alignment alternatives, diameter, hydraulics, depth alternatives and the siting of various tunnel components.

## 3.1 TUNNEL VOLUME

Although the Fall Creek/White River Tunnel project will provide environmental benefits by capturing a majority of the CSO outfalls, the project as currently envisioned provides no significant flood control benefit. Therefore, the size of the Fall Creek/White River Tunnel will be determined by the CSO percent capture established in the Long Term Control Plan (LTCP), which is under negotiation with the regulatory agencies as of the writing of this report. Although the tunnel will be configured to convey water from the CSOs to the Deep Tunnel Pump Station located at the southern end of the tunnel, its primary function will be CSO storage. Main tunnel sizes that provide 95, 97 and 99 percent capture of CSOs were considered. Table 3.1 lists the CSO volumes at 95, 97 and 99 percent capture.

**Table 3.1**
**CSO Volume at Various Percent Capture[1]**

| Percent Capture | Fall Creek CSOs, gallons | White River CSOs, gallons | Total Volume of CSOs, gallons |
|---|---|---|---|
| 95 | 76,000,000 | 113,500,000 | 189,500,000 |
| 97 | 110,000,000 | 200,000,000 | 310,000,000 |
| 99 | 162,000,000 | 342,000,000 | 504,000,000 |

[1]CSO volumes were provided by the Indianapolis Clean Stream Team and based on CSO Long Term Control Plan development efforts.

# 3. FALL CREEK/WHITE RIVER TUNNEL

## 3.2 TUNNEL ALTERNATIVES

Route and depth alternatives were identified and evaluated for the main tunnel and connection tunnels. The tunnel routes generally follow the Fall Creek and White River to capture CSO discharges along these waterways. This corridor was selected to minimize the length of the main tunnel and connection tunnels that connect the drop shafts to the main tunnel.

A significant portion, if not all, of the main tunnel will be mechanically excavated using a tunnel boring machine (TBM). This mining method is expected to be the most economical for the long, large diameter tunnel in the anticipated geologic environment. TBMs are most productive when mining in a relatively straight line and constant slope. The slope of the Fall Creek/White River Tunnel can be kept constant if necessary, but the routes require some curvature to economically convey the CSOs to the main tunnel. Long sweeping curves and compound curves should be avoided along the routes to minimize complications while mining the tunnel. The routes have been configured to limit the minimum radius of curvature to 1,200 feet. Radii tighter than 1,000 feet can be negotiated by the TBM, but are more difficult and costly to excavate in this size range. Very small radii curves would require excavation by less productive methods, such as drill-and-blast mining. If a tight curve is constructed, the TBM may need to be re-launched by physically moving the TBM from the start to the end of the drill-and-blast excavated curve, which decreases productivity and increases cost. A large diameter shaft or an over-excavated underground chamber may be necessary to move and re-launch the TBM. Therefore, the main tunnel alignment alternatives have been routed in a manner to conform to radius constraints of a conventional TBM.

Whenever possible, the tunnel alignments were routed to avoid being directly below the Fall Creek and White River. All of the drop shafts will be located on land outside of these water bodies to reduce construction risk and costs. It is conceivable that during the tunnel excavation, unforeseen conditions may occur that cannot be resolved at the tunnel face. Therefore, additional access shafts may be required along the tunnel alignment to resolve the situation. In this case, an access shaft on land is preferred to one located in the creek or river. Locating the tunnel mainly under land adjacent to the waterways also allows for periodic alignment check and concrete drop holes, as necessary.

### 3.2.1 Route Alternatives

Three alternative routes within the alignment corridor were identified for the main tunnel. The alternative routes include:

- West Alignment
- Central Alignment
- East Alignment

These alignments and the associated drop shafts are shown on Figure 3.1. The alternatives follow identical alignments south of Oliver Avenue along White River and north of 24$^{th}$ Street along Fall Creek. Between Oliver Avenue and 24$^{th}$ Street, the alignments diverge to the routes identified as the West Alignment, Central Alignment and East Alignment. The West, Central and East Alignment and corresponding connection tunnels are presented on Figures 3.2 through 3.4. The alternatives also include site options for the working and retrieval shafts. Following the completion of geotechnical exploration programs, further refinements of each alignment may be necessary. These adjustments also may be necessary for the shared portions of the alignments south of Oliver Avenue and north of 24$^{th}$ Street.

# 3. FALL CREEK/WHITE RIVER TUNNEL

INSERT FIGURE 3.1

INSERT FIGURE 3.2

# 3. FALL CREEK/WHITE RIVER TUNNEL

INSERT FIGURE 3.3

# 3. FALL CREEK/WHITE RIVER TUNNEL

INSERT FIGURE 3.4

# 3. FALL CREEK/WHITE RIVER TUNNEL

The alternative routes were developed considering the following primary criteria:

- Minimize the length of the connection tunnels
- Maximize the distance between the tunnel and well fields
- Remain within TBM radii constraints while minimizing curvature of the route (vertical alignment is constant slope)
- Minimize the length of the main tunnel
- Minimize the potential impacts to vibration sensitive and high value structures/activities, such as hospitals, museums, convention centers, river-front facilities, etc.
- Minimize impact to the public
- Minimize socio-economic impacts, such as disruptions to industrial and commercial businesses
- Minimize the required easements and land acquisition
- Minimize the probability of encountering environmental contamination
- Minimize tunnel alignment directly under Fall Creek and White River

<u>West Alignment</u>

As shown on Figure 3.2, the West Alignment begins at one of three working shaft alternatives and follows the White River approximately 2,000 feet north of the confluence of Fall Creek. The alignment passes through the Riverside Well Field and trends to the northeast until reaching the Fall Creek near CSO outfall 050 adjacent to Watkins Park. The tunnel continues eastward along 24$^{th}$ Street to CSO outfall 052 north of Barton Park. The tunnel turns to the northeast and generally follows Fall Creek to one of the retrieval shaft alternatives.

The main tunnel of the West Alignment is 50,290 feet long between the Bluff Road working shaft site south of Pleasant Run and the Sutherland Avenue retrieval shaft site west of the intersection of 35$^{th}$ Street and Sutherland Avenue. Approximately 20,170 feet of various diameter connection tunnels along the alignment are associated with this alternative. This is the longest alignment of the three

# 3. FALL CREEK/WHITE RIVER TUNNEL

alternatives. Therefore, the tunnel would have the smallest diameter to accommodate the required CSO volume.

Central Alignment

As shown on Figure 3.3, the Central Alignment is the same as the West Alignment south of Oliver Avenue along the White River and north of 24th Street along the Fall Creek. North of Oliver Avenue, the tunnel follows University Boulevard until turning northwest near 10th Street, where it crosses under Fall Creek Park and Fall Creek. Approximately 1,000 feet west of Fall Creek but east of the Riverside Well Field, the tunnel turns back to the north. The tunnel follows Milburn Street for about 4,000 feet before heading east around the White River Well Field. The tunnel continues east approximately 2,000 feet until it reaches Fall Creek where it turns to the northeast and generally follows the creek to the retrieval shaft.

The main tunnel of the Central Alignment is 47,240 feet long between the Bluff Road working shaft and the Sutherland Avenue retrieval shaft. Approximately 25,280 feet of various diameter connection tunnels along the alignment are associated with this alternative.

East Alignment

As shown on Figure 3.4, the East Alignment is also the same as the other alternative alignments south of Oliver Avenue and north of 24th Street. North of Oliver Avenue, the tunnel follows University Boulevard for approximately 2,000 feet. The tunnel proceeds northeast for approximately 3,000 feet until reaching Dr. Martin Luther King Jr. Street near 12th Street. The tunnel turns north and follows Dr. Martin Luther King Jr. Street for approximately eight city blocks. The tunnel heads northeast and crosses under Interstate 65 before reaching Fall Creek near CSO outfall 051 at Barton Park. The tunnel then generally follows Fall Creek to the retrieval shaft.

The main tunnel of the East Alignment is 44,200 feet long between the Bluff Road working shaft and the Sutherland Avenue retrieval shaft. Approximately 28,390 feet of various diameter connection tunnels along the alignment are associated with this alternative. Of the three alternatives, the East Alignment is the shortest but has more connection tunnels with longer lengths and the largest diameter.

### 3.3 TUNNEL DIAMETER

The main tunnel alignment will be bound by Keystone Dam on Fall Creek to the north and the future Interplant Connection Structure near CSO outfall 117 to the south. This corridor encompasses the capture of 43 CSO outfalls along the Fall Creek and White River. Depending on the selected alignment and percent capture, the tunnel length can vary from 7.5 to 10.5 miles. The tunnel diameter will vary based on the length. Table 3.2 summarizes the main tunnel finished diameter associated with 95, 97, and 99 percent capture for the selected tunnel alignments extending from the Bluff Road working shaft to the Sutherland Avenue retrieval shaft.

**Table 3.2**
**Main Tunnel Finished Diameters**

| Tunnel Alignment[1] | Main Tunnel | | |
|---|---|---|---|
| | 95 Percent Capture, ft | 97 Percent Capture, ft | 99 Percent Capture, ft |
| West | 26 | 33 | 42 |
| Central | 27 | 34 | 43 |
| East | 27 | 35 | 45 |

[1] Based on Bluff Road working shaft site and Sutherland Avenue retrieval shaft site.

There are a number of contractors in the United States that have experience in the construction of water tunnels with finished diameters up to 35 feet. However, tunnels with 42 to 45-foot finished diameters conveying and/or storing water are rare across the globe and to Black & Veatch's knowledge have not been constructed in the

United States. It is our understanding that a long, 40 to 45-foot diameter tunnel is being considered for a hydropower project in the Northeast and that TBMs can be constructed to excavate this diameter. However, it is anticipated that the number of contractors experienced with these size tunnels and machines is extremely limited and although unpredictable, the escalation of project costs could be prohibitive. In addition, limited geotechnical data exists for the tunnel alignment to evaluate the feasibility and cost effectiveness of excavating such a large diameter deep rock tunnel in Indianapolis. For these reasons, it is recommended that no further consideration be given to sizing the main tunnel for 99 percent capture within this project corridor.

The tunnel system should be designed to facilitate expansion of the main tunnel to accommodate 99 percent capture in the future, as requested by the City of Indianapolis Department of Public Works (DPW). This requires the consolidation sewers, drop shafts and connection tunnels to be sized for 99 percent capture. The main tunnel will be sized for 95 or 97 percent capture with the ability to extend the tunnel to increase the system storage capacity to provide 99 percent capture. If expanded in the future to provide 99 percent capture, the 95 percent capture tunnel, at the corresponding diameters indicated in Table 3.2, would need to be expanded approximately 80,000 linear feet or roughly 15.2 miles. Likewise, if expanded in the future to provide 99 percent capture, the 97 percent tunnel, at the corresponding diameters indicated in Table 3.2, would need to be expanded approximately 30,000 linear feet or roughly 5.7 miles.

### 3.4 TUNNEL HYDRAULICS AND OPERATIONAL CONSIDERATIONS

During the early stages of a wet weather event, a CSO entering the tunnel system will flow by gravity into the consolidated sewer. It will then flow down a drop shaft and through a connection tunnel to the main tunnel. The water will flow by gravity to the Deep Tunnel Pump Station, connected to the main tunnel. Once the maximum level in the tunnel system has been reached, CSO will be actively diverted using mechanical and automated controls to prevent it from entering the tunnel system.

# 3. FALL CREEK/WHITE RIVER TUNNEL

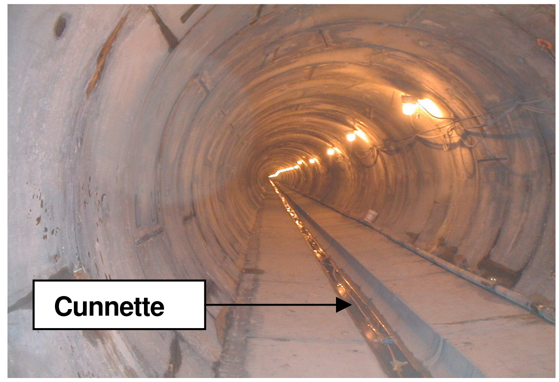
Any remaining wet weather flow will discharge as CSO at an emergency outfall that will be located downstream from any adjacent public gathering place. The Deep Tunnel Pump Station will be the only means for removing CSOs from the tunnel.

The consolidation sewers, drop shafts and connection tunnels will be sized to provide 99 percent capture of CSO, as requested by DPW. The main tunnel and control structures will be sized to provide either 95 or 97 percent capture. The main tunnel will have the flexibility to provide the necessary volume to achieve 99 percent capture by extending the length in the future.

The maximum fill level or hydraulic grade line in the tunnel system should remain below the groundwater level. This will assist to maintain an inward gradient and limit CSO exfiltration out of the tunnel. Although the tunnel system will be fully lined, if it fills above the groundwater level, an outward gradient into the surrounding aquifer will develop. Therefore, each consolidation sewer should have controls to avoid this situation. These controls typically are required to not only prevent exfiltration from the tunnel but to receive regulatory approval when passing through an aquifer. The tunnel system is adequately sized based on preliminary storage requirements for 95 or 97 percent capture volumes.

The tunnel will slope downward towards the Deep Tunnel Pump Station from north to south. The tunnel grade must permit minimum solids or particles carrying velocities of 2.5 to 3.5 feet per second while limiting the additional depth associated with steeper grades. With a constant downward grade of 0.1 percent, the velocity would exceed the recommended minimum when the water level in the tunnel is only one to two feet deep.

At higher water levels, the velocity will increase and at lower water levels the velocity will decrease. To increase the velocity at lower water levels, a channel, or cunnette, could be constructed in the invert of the tunnel. The need for a cunnette should be determined during design when evaluating the tunnel hydraulics. Higher flow velocity can be anticipated during filling events when the flow in the tunnel is not controlled by the Deep Tunnel Pump Station but rather by the tunnel slope and size. Therefore, the cunnette may not be necessary due to the higher velocity flows that are anticipated during the initial stages of a filling event that will induce scour of the deposited sediment. If, during design, a cunnette is determined to be necessary, the size of the main tunnel should be verified to ensure the desired percent capture volume is obtained while considering the storage volume lost due to the construction of the cunnette.




**Channel or Cunnette in CSO Tunnel**

### 3.5 TUNNEL DEPTH ALTERNATIVES

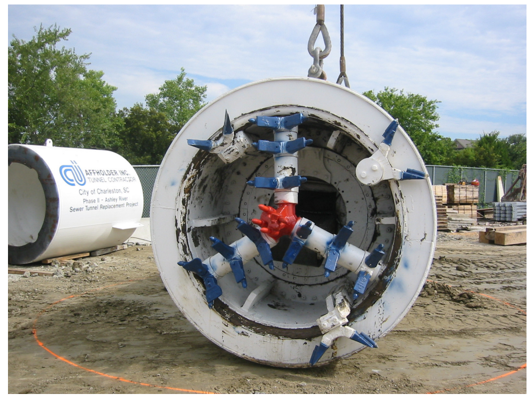
Three alternatives were evaluated for the horizon of the main tunnel as follows:

- Soft ground tunnel – shallow tunnel that is constructed in the soil.
- Mixed-face tunnel – shallow to relatively deep tunnel that is constructed in both soil and rock.
- Rock tunnel – deep tunnel constructed in rock.

<u>Soft Ground Alternative for Main Tunnel</u>

Available geologic data indicates that variations in the soil thickness can be expected along the Fall Creek and White River. In the area of the proposed tunnel routes, the soils generally range from 65 to 120 feet thick. These soils consist primarily of saturated sands that constitute a significant aquifer along Fall Creek and White River.

# 3. FALL CREEK/WHITE RIVER TUNNEL



**Soft Ground Cutter Head**

The main tunnel's crown needs to be below the current CSO regulator inverts and consolidation sewers along the alignment to allow gravity flow into the system. The CSO regulator inverts are estimated to be approximately 15 to 30 feet below ground surface (bgs) measured from above the river embankment. Therefore, the tunnel's crown would need to be at least 30 to 35 feet bgs at the upper reaches of the tunnel along Fall Creek. Depending on the selected percent capture (95 or 97 percent), the invert at the northern reach will be about 60 to 70 feet bgs. Given that the tunnel slopes at a 0.1 percent grade, the tunnel invert at the Deep Tunnel Pump Station would be approximately 110 to 120 feet bgs.

A soft ground main tunnel is not feasible due to the gravity flow requirements and the anticipated depth to rock range of 65 to 120 feet along the alignment. The tunnel would be constructed in mixed-face conditions within the tunnel horizon at these proposed depths.

<u>Mixed-Face Alternative for Main Tunnel</u>

Tunneling through a mixed-face is typically avoided if other options are available because of the technical complexities and costs associated with this horizon. Risks associated with crossing the transition from soil to rock and rock to soil are heightened due to the increased difficulties in excavating, controlling grade, and supporting the tunnel in drastically different and varying media. Although mining in a mixed-face using TBMs specifically designed for the conditions has been done with limited success, the geology in Indianapolis makes this horizon unfeasible. In Indianapolis, the risk is magnified because of the potential for high groundwater inflows and the drastic difference between excavating saturated sand and limestone or dolomite. Production rates would be significantly less and the risk of failure is exponentially higher if the tunnel was placed at this depth. Since other vertical alignment options are feasible, the mixed-face tunneling horizon has been avoided as a risk management step and will not receive further consideration.

Rock Alternative for Main Tunnel

Rock tunnel excavation methods include using TBMs, drill-and-blast mining, and roadheaders. TBMs are the most economical tunneling method for a main tunnel of this length and diameter because of their greater productivity. It is anticipated that the limestone and dolomite rock along the Fall Creek/White River Tunnel alignment can be bored using a TBM. Drill-and-blast mining would be employed to construct some of the connection tunnels (adits); although roadheaders may have limited application. A roadheader's primary mining component is a rotating cutter that is attached to a boom.

**Rock Tunnel Cutter Head**

Siting the main tunnel in rock will provide a more uniform excavation than a soft ground or mixed-face tunnel. Rock tunnels progress more favorably in consistent, intact rock that is not excessively strong, tough or abrasive and does not contain large solution features and broken rock zones. Open joints and solution features are present in the rock units in and around Indianapolis based on available geologic information. Properly designed and executed geotechnical exploration programs along the alignment are necessary to select the depth of the main tunnel to avoid undesirable features to the extent practical.

# 3. FALL CREEK/WHITE RIVER TUNNEL

Current data indicates that carbonate rocks of the Devonian and Silurian Systems interbedded with shale units underlie the soils. These carbonate units are productive aquifers in the area and have open joints to depths of 100 feet below the top of rock and deeper. Pressure testing the rock in intervals during geotechnical investigation programs will allow the tunnel horizon to be established within a competent rock of lower permeability. Due to limited alignment-specific geologic information, the preliminary tunnel horizon was established using a rule-of-thumb of two tunnel diameters of rock above the tunnel crown. This is recommended to obtain a self-supporting rock formation above the tunnel crown and attempt to minimize the risk of encountering weathered zones, solution features, and sediment infilled bedrock surface valleys or depressions. Although weathering effects typically lessen with depth, this requires further evaluation during future geotechnical exploration programs. The appropriate tunnel horizon should be established during design using the site-specific data gathered from the geotechnical exploration programs.

Conservatively estimating that the bedrock surface is 120 feet bgs, the tunnel invert will be approximately 210 feet bgs at the northern end of the alignment. This invert depth was calculated by adding the 120 feet of overburden to two 30-foot tunnel diameters of rock above the crown of a 30-foot diameter tunnel. Thirty (30) foot is the average tunnel diameter to achieve 95 and 97 percent capture. The tunnel invert will be approximately 260 feet bgs at the southern end of the alignment with a 0.1 percent slope. At this invert depth, based on current geologic information, it is anticipated that the tunnel would be mined primarily through the limestone and dolomite rock units of the Lower Devonian and Upper Silurian Systems, as illustrated on Figure 3.5. The appropriate tunnel depth should be determined following evaluation of the rock during future geotechnical exploration programs.

## 3.6 TUNNEL SHAFTS

Tunnel shafts will be used to launch and retrieve the TBM, provide ventilation to the tunnel, convey CSOs from the consolidation sewers to the tunnel system, and house

# 3. FALL CREEK/WHITE RIVER TUNNEL

INSERT FIGURE 3.5

the Deep Tunnel Pump Station and screening facility. The tunnel shafts also provide access to the tunnel system during construction and for operation and maintenance purposes.

Due to the anticipated depth of the main tunnel and the relatively consistent ground surface elevation along the entire project alignment, all of the shafts are expected to be vertical, as opposed to gently sloping portals.

### 3.6.1 Primary Working Shaft

The primary working shaft is expected to be 40 to 50 feet in diameter, depending on the percent capture (95 or 97) for the main tunnel. The primary working shaft area will require six or more acres of land to stage the following work:

**Typical Working Shaft Area**
**(Milwaukee NWSR Tunnel Site)**

- TBM assembly
- Muck removal
- Staging of construction materials
- Labor and materials point of entry into the tunnel
- Ventilation
- Tunnel groundwater handling and treatment

The land also will be used for the following permanent facilities:

- Screening shaft (converted working shaft)
- Structures and equipment for removing screenings
- Deep Tunnel Pump Station
- Pump removal and installation equipment
- Equipment storage and handling areas

# 3. FALL CREEK/WHITE RIVER TUNNEL

- Power facilities
- Instrumentation
- Odor control
- Maintenance facilities

Permanent easements will be required for a portion of this property, if not currently owned by the City of Indianapolis (City), to access the screening facility and the Deep Tunnel Pump Station.

Potential working shaft sites were selected based on the following considerations:

- Acquirable land
- Close proximity to the White River and the future Interplant Connection Structure near CSO outfall 117
- Convenient site for haul routes to and from the highway
- No known soil or groundwater contamination
- Minimal impacts to the community and public
- Presence of few to no structures, particularly sensitive or high-value structures
- Accessible water discharge point
- Power availability

Site selection also considered disruptions to the community and adjacent structures from truck traffic, blasting, noise, lighting and air quality. Mucking operations could generate more than 120,000 truckloads of material to be hauled off-site. Convenient access to the site is paramount to minimizing traffic congestion. Therefore, detailed haul-route and muck disposal planning will be required during the project design. Construction activities also may require working hour restrictions, which will impact tunnel construction productivity and duration.

Three potential working shaft sites were identified, including the Reilly shaft site, Southern Avenue shaft site, and the Bluff Road shaft site. The working shaft sites are presented on Figures 3.1 through 3.4.

# 3. FALL CREEK/WHITE RIVER TUNNEL

Reilly Working Shaft Site

As shown on Figure 3.1, the Reilly working shaft alternative is located in the Lilly Industrial Park, north of Raymond Street and west of the White River and White River Parkway. The property is over six acres and currently is a vacant field. Although the site allows the tunnel route to remain along the White River, it is not in close proximity to CSO outfalls 012 and 117 and the future Interplant Connection Structure. This site adds significant length to connect the CSO drops to the main tunnel. In addition, the pipeline between the Deep Tunnel Pump Station and the Interplant Connection Structure would require tunneling to cross the White River.

**Reilly Working Shaft Site**

The site is located in an industrial district and is easily accessible by taking Raymond Street to either Highway 67 or Interstate 65. Impacts to the public from operations conducted at the shaft would be minimal. The presence of contamination at the property is suspected, but needs to be further investigated or confirmed during the geotechnical exploration program prior to recommending this site. According to a historic geological map, a portion of this property was formerly a pond, which appears to have been filled. The Phase I Environmental Site Assessment (ESA) did indicate the site is within the proximity of an old landfill and has the potential to be contaminated (see Appendix D).

# 3. FALL CREEK/WHITE RIVER TUNNEL

Southern Avenue Working Shaft Site

As shown on Figure 3.1, this shaft site is located at the southeast corner of the Bluff Road and Southern Avenue intersection. The four-acre property is owned by the City of Indianapolis Department of Parks and Recreation (DPR), and currently is not being used. This site would be functional if an additional off-site support area was used for staging materials. The Southern Avenue shaft site is close to the White River, the future Interplant Connection Structure and CSO outfall 117.

**Southern Avenue Working Shaft Site**

The site is bordered by Pleasant Run to the south and east, Bluff Road to the west, and Southern Avenue and St. Joseph & Holy Cross Cemetery to the north. The site is accessible by taking Bluff Road, Troy Avenue and Harding Street to Interstate 465. This route currently carries a sizable amount of truck traffic. The presence of contamination at the property is unknown and would need to be investigated during the geotechnical exploration program prior to selecting this site. The Phase I ESA did not indicate the site as being contaminated.

The City of Indianapolis DPR indicated that there is a long range plan for this site. The site is intended to ultimately become the trail head for the Pleasant Run Greenway Trail, once the trail has been extended to this location. There was no timeline provided for this long-term planned improvement. Short-term improvements will include the demolition of the current structure on site and the inclusion of a gravel parking lot for public use. The short-term improvements are expected to occur within the next two years.

# 3. FALL CREEK/WHITE RIVER TUNNEL

Bluff Road Working Shaft Site

Multiple potential shaft sites were identified in a commercial area along Troy Avenue between Bluff Road and the Illinois Central Railroad tracks. Many of the businesses use the lots for tractor trailer storage. The most promising site identified in this area is a commercial property owned by Egenolf that is currently for sale. The property is located west of Bluff Road and north of Troy Avenue as shown on Figure 3.1. The property is located in an industrial area. It is over 20 acres in size with the back half of the property (approximately 10 acres) open with no structures. Currently, this back lot is used for tractor trailer storage. This site is in close proximity to CSO outfall 117 and the future Interplant Connection Structure.

The presence of contamination at the property is not anticipated. The Phase I ESA did not indicate site contamination, and an environmental report was provided by the current property owner that indicated the site is not contaminated. Follow-up soil sampling was also conducted by the current owner, which showed no evidence of contamination.

**Bluff Road Working Shaft Site**

The Bluff Road working shaft site is preferred because of its size, availability and close proximity to CSO outfall 117 and the future Interplant Connection Structure. The site is large; offers plenty of room for the working shaft site; and can be sub-parceled. In addition, the site has facilities that could serve as equipment storage and an office for construction management staff during tunneling activities.

### 3.6.2 Intermediate Working Shafts

It is anticipated that at least one of the drop shafts locations, preferably midway along the alignment, will serve as an intermediate working shaft. This shaft will provide access to the tunnel, facilitate the delivery of supplies to the miners and provide access for removal of muck. The intermediate working shaft also will minimize delays associated with long distances if only a primary working shaft is constructed.

The intermediate working shaft also may be used to retrieve the TBM if multiple tunnel contracts are used to complete the project. If two main tunnel contracts are desired, the intermediate working shaft location would be the most appropriate place to segment the two contracts. If the main tunnel is segmented into two contracts, it is anticipated that the intermediate working shaft could be used for both tunneling contracts if properly coordinated. This shaft would serve primarily as the working shaft for the north tunnel contract. Depending on the timing of the two contracts, the contractor for the south tunnel could use this shaft for TBM retrieval or the TBM would be backed out of the tunnel to the primary working shaft for removal. In this case, the cutterhead would be removed at the retrieval shaft.

The size of the intermediate working shaft will vary depending on its function. If it is constructed as an access point midway along the alignment, the shaft is anticipated to be 20 to 25 feet in diameter. If it is used to retrieve or launch the TBM, the shaft may be 40 to 50 feet in diameter.

Intermediate working shafts were identified for the West, Central, and East Tunnel Alignments and are shown on Figures 3.2, 3.3, and 3.4, respectively and are discussed in more detail below.

# 3. FALL CREEK/WHITE RIVER TUNNEL

West Alignment Intermediate Working Shaft Site

The southeast corner of the Bush Stadium parking lot was identified as the proposed intermediate working shaft location for the West Alignment. This location corresponds with drop shaft DS-08 shown on Figure 3.2. The parking lot is owned by the City and is currently leased to Indiana University-Purdue University Indianapolis (IUPUI). It is bordered by the White River to the south, Bush Stadium to the north, and commercial properties to the east and west. Interstate 65 can be accessed by taking 16th Street east to Dr. Martin Luther King Jr. Street and proceeding north to 21st Street. The access ramp to the interstate is east on 21st Street.

**West Alignment Intermediate Working Shaft Site**

Central and East Alignment Intermediate Working Shaft Site

The proposed intermediate working shaft location for the Central and East Alignments is the same. The shaft site is located in Barton Park between Fall Creek and Fall Creek Parkway at drop shaft DS-12 as shown on Figures 3.3 and 3.4. The site is bordered by Fall Creek to the east and west, Fall Creek Parkway and Interstate 65 to the west, and residential properties to the north/ northeast. The site is owned by the City and is currently an open field with a few

**Central and East Alignment Intermediate Working Shaft Site**

# 3. FALL CREEK/WHITE RIVER TUNNEL

trees. Interstate 65 can be accessed by taking the bridge south of Barton Park to the 21st Street interstate access ramp.

### 3.6.3 TBM Retrieval Shaft

It is anticipated that a 40-foot diameter retrieval shaft will be used to remove the TBM. A smaller diameter retrieval shaft could be constructed to remove the TBM cutterhead. The TBM cutterhead would be segmented into smaller pieces so it could be retrieved through the smaller diameter shaft. The remainder of the TBM and associated trailing gear could be backed out of the excavated tunnel to the working shaft or intermediate working shaft for retrieval.

Two retrieval shafts along Fall Creek were identified at the northern extent of the tunnel alignment. The Sutherland Avenue and Keystone Dam retrieval shafts are shown on Figures 3.1 through 3.4. Both retrieval shafts could serve as a drop shaft location and eliminate the need for a drop shaft on the alignment as described below.

Sutherland Avenue Retrieval Shaft Site

As shown on Figure 3.1, this shaft site is located north of CSO outfall 065, east of the Fall Creek, and west of the Sutherland Avenue and 35th Street intersection. The property is owned by the Norfolk and Western Railroad and would require crossing their railroad track along Sutherland Avenue. The vacant lot is greater than two acres and currently brush covered. Drop shaft DS-17 would be eliminated by using this retrieval shaft to drop the flow from CSO outfall 065 into the tunnel system.

**Sutherland Avenue Retrieval Shaft Site**

# 3. FALL CREEK/WHITE RIVER TUNNEL

Keystone Dam Retrieval Shaft Site

As shown on Figure 3.1, this shaft site is located near Millersville Road and the Norfolk and Western Railroad track east of Keystone Avenue. The area consists of three properties owned by Precision Metal, the Town of Fishers and the City of Indianapolis. Access to the two-acre site would require a temporary road to cross the railroad tracks. Drop shaft DS-20 would be eliminated by using this retrieval shaft to drop flow from CSO outfall 135 into the tunnel system.

**Keystone Dam Retrieval Shaft Site**

## 3.7 GEOTECHNICAL DESIGN CONSIDERATIONS

The geology and hydrogeology along the route will be controlling factors in finalizing the horizontal and vertical alignments of the main tunnel and connection tunnels; and the selection of tunneling and shaft construction methods. The geotechnical information available to date indicates the overburden thickness along the alignment generally ranges from 65 to 120 bgs. The underlying rocks are primarily Devonian and Silurian age carbonate units with some interbedded shale layers. A layer of Devonian age shale is anticipated to be present directly below the overburden along the southernmost portion of the project area. Depth to rock can vary significantly over a short distance along the Fall Creek and White River.

The overburden soils contain sand and gravel units that are interconnected to the creek and river and are productive aquifers in the area. These surficial aquifers are connected hydraulically to underlying limestone and dolomite rocks along the project alignment. Dewatering the surficial or bedrock aquifer adjacent to the Fall Creek and

# 3. FALL CREEK/WHITE RIVER TUNNEL

White River is expected to be difficult and costly, if not impractical. When these areas cannot be avoided, zones of high groundwater inflow can be addressed by either improving the ground prior to excavation by pre-excavation grouting or by using a water-tight construction method.

Layers of clayey sediments and tills are known to be intercalated with the sand and gravel. Potentially, these clayey sediments could consolidate due to dewatering and produce settlement. Additionally, tills can contain boulders that are an impediment to mechanical excavation. Although boulders have not been encountered consistently in the overburden, their presence can complicate shaft and soft ground tunnel construction because they can be difficult and problematic to remove. Developed joints, faults, and fractures that extend 100 feet into these rock units also can provide a significant yield of groundwater. Adverse geologic and hydrogeologic conditions that also may affect tunneling productivity include:

- Faults
- Weak zones in the rock
- Solution features (filled or void)
- Large groundwater inflows
- Mixed-face
- Hazardous and explosive gases
- Cobbles, boulders, and/or obstructions

The tunnel corridor does not contain any major faults that have been mapped. However, minor faults of one to two feet of thrust displacement should be anticipated along the tunnel routes. Zones of weak rock and solution features, both of which can be associated with large groundwater inflows, are present in the Devonian and Silurian age bedrock formations and can be expected in the project area. When solution features filled with sand and gravel are encountered, tunneling production can be complicated and slowed considerably. The ability to handle unexpected flowing ground at the tunnel face will factor into the production rate. These zones will require additional ground improvement efforts prior to tunneling and additional

# 3. FALL CREEK/WHITE RIVER TUNNEL

ground support to maintain a stable tunnel and safe working environment. Data collected from geotechnical exploration programs will be necessary to site the tunnel at the most appropriate depth that minimizes interference with these features.

There is potential for the presence of hazardous and explosive gases, particularly hydrogen sulfide and methane in the rock. Low levels of hydrogen sulfide typically can be detected in the subsurface and managed with ventilation systems. High levels of hydrogen sulfide can occur with high levels of groundwater inflows and will require additional controls while tunneling. The presence of hazardous and explosive gases in the subsurface should be evaluated during future geotechnical exploration programs. This data will assist in determining the selection of the tunnel excavation methods.

## 3.8 GROUNDWATER IMPACT CONSIDERATIONS

Groundwater will require significant consideration during the design and construction of the tunnel for following reasons:

- Groundwater is present in abundant quantities at a shallow depth in the overburden (granular soil)
- The overburden is a prolific aquifer along the Fall Creek and White River
- The overburden is typically underlain by jointed, water-producing limestone and dolomite rock units
- Hydraulically-connected solution features may be present in the top 100 feet of rock
- Fall Creek and Riverside-White River wells are pumped from the overburden and bedrock aquifers along the project corridor

During shaft excavation, it will be necessary to control groundwater by dewatering the ground, constructing cut-off barriers, or using water-tight construction techniques. It is expected that dewatering will be limited to shallow shafts that are away from Fall Creek and White River. This will limit any potential negative impacts caused by dewatering, such as reduced well yields and settlement by consolidation. If adverse impacts to the water supply occur, dewatering activities would cease until further investigation can be completed. The feasibility of dewatering the overburden for shaft construction along Fall Creek or White River is highly questionable given the direct connection of the waterways to the surficial aquifer. It is anticipated that dewatering the rock and the overlying soil to a water level below the base of the excavation will not be technically feasible or cost effective during deep shaft construction because the shafts will be located in a productive aquifer. When constructing deep shafts, it is critical that the groundwater control techniques used in soil are compatible with the groundwater control techniques used in rock to minimize groundwater infiltration at the soil/rock interface to a manageable volume.

Groundwater also will be a significant constructability issue for the Fall Creek/White River Tunnel and the connection tunnels. This issue is magnified where the tunnels pass near the Fall Creek and Riverside-White River well fields. Water wells along the alignment will require monitoring for adverse impacts before, during, and after tunnel construction. Potential impacts to the well fields include lowering of the water table during and after tunneling and CSO exfiltration once the lined tunnel is operational. A groundwater model simulating the dewatering effects of the tunnel should be considered necessary during design.

For the main tunnel and connection tunnels constructed in rock, options to control groundwater at the face include modifying the ground before excavation using pre-excavation grouting or tunneling with a water-tight system. Although the geologic and hydrogeologic properties of the rock require further definition, it is anticipated that conducting pre-excavation grouting will be the most successful and cost effective technique to control groundwater. Water-tight systems, such as a pressurized face earth pressure balance machine (EPBM) with gasketed pre-cast concrete lining segments are costly and not recommended for rock tunnels under a high groundwater pressure. It is recommended that more conventional and cost effective tunneling methods be employed. In the surficial aquifer, it is anticipated that dewatering along the soft ground connection tunnel alignments will not be feasible. Therefore, a water-tight groundwater control system will be required.

### 3.9 CONTAMINATED MATERIAL CONSIDERATIONS

Due to the impact on the construction schedule, contaminated soil and/or groundwater along the tunnel alignment should be considered during the design and construction of the tunnel. During design, it is important to identify contamination in the project area and determine the nature and extent of the contaminants so the impact to construction can be evaluated. This is particularly true at shaft locations where the potential to encounter contamination is higher due to soil excavation. If contamination is present in the project area, it is expected to be more prevalent in soil than in deeper rock. However, the presence of contamination in rock and the groundwater flowing through the rock also must be considered. Shaft relocations or tunnel alignment adjustments during construction due to contamination will adversely impact the schedule and project cost. Therefore, soil and ground water sampling and testing during project planning and design are necessary at shaft locations and along the main and connection tunnel alignments.